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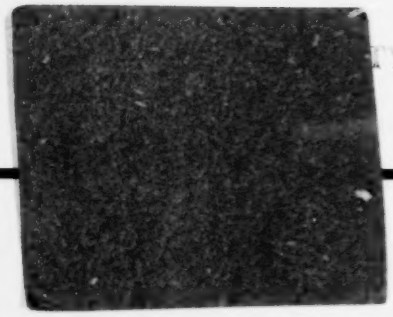

COMMITTEE ON THE PEACEFUL
USES OF OUTER SPACE

REPORT ON THE UNITED NATIONS/EUROPEAN SPACE AGENCY SYMPOSIUM ON SPACE INDUSTRY COOPERATION WITH THE DEVELOPING WORLD, CO-SPONSORED BY THE EUROPEAN SPACE AGENCY AND THE GOVERNMENT OF AUSTRIA

(Graz, Austria, 8-11 September 1997)

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INTRODUCTION

A. Background and objectives

1. The General Assembly, in its resolution 37/90 of 10 December 1982, decided that in accordance with the recommendations of the Second United Nations Conference on the Exploration and Peaceful Uses of Outer Space (UNISPACE 82),[1] the United Nations Programme on Space Applications should, *inter alia*, promote greater cooperation in space science and technology between developed and developing countries, as well as between developing countries.

2. The Committee on the Peaceful Uses of Outer Space at its thirty-ninth session, held in June 1996, endorsed the programme of workshops, training courses and seminars proposed for 1997 by the Expert on Space Applications.[2] Subsequently, the General Assembly, in resolution 51/123 of 13 December 1996, endorsed the United Nations Programme on Space Applications for 1997.

3. In response to General Assembly resolution 51/123 and in accordance with the UNISPACE 82 recommendations, the Symposium on Space Industry Cooperation with the Developing World was jointly organized by the United Nations and the Government of Austria at Graz, Austria, from 8 to 11 September 1997. The Symposium was co-sponsored by the Federal Ministry for Foreign Affairs of Austria, the province of Styria, the city of Graz and the European Space Agency (ESA). The Federal Ministry also acted as host of the Symposium, which served as follow-up to the United Nations/European Space Agency/European Commission Symposium on Space Technology Applications for the Benefit of Developing Countries, held at Graz from 9 to 12 September 1996.

4. The main objective of the Symposium was to provide an opportunity for representatives of space industry and the private sector to interact with international space scientists, space technology experts and policy makers from developing and developed countries and to explore possibilities for increased scientific and technical cooperation. Industry and private ventures had become important players in the space applications sector, and by demonstrating to participants the capabilities offered by space technology, as well as the problems usually encountered in developing and using space applications, they might have a greater understanding of the type of requirements that had to be met for a successful commercial venture.

5. Such information could help to convince policy makers and other decision makers in developing countries of the value of allocating resources to implement such applications in support of national and regional development.

6. The present report was prepared for the forty-first session of the Committee on the Peaceful Uses of Outer Space and the thirty-fifth session of its Scientific and Technical Subcommittee. The detailed proceedings of the Symposium, including a list of addresses of all the participants, will be made available in due time.

B. Programme

7. At the opening of the Symposium welcoming statements were made by representatives from the United Nations, ESA and the host country. The programme of the Symposium was divided into a series of sessions, each addressing a specific issue. The invited presentations were followed by panel discussions and brief presentations by participants from developing countries on the theme of the Symposium, describing the status of space technology applications in their respective countries.

8. The different sessions focused on opportunities for and problems of technology exchange in space applications, with special consideration for small satellite platforms, the use of satellite telecommunications for

regions with underserved telecommunications infrastructures, the role of space systems for tele-education and telehealth applications, the distribution of data acquired by remote sensing satellites to the end-user, the potential of space technology for agricultural monitoring and precision agriculture, as well as navigation and localization systems and services. All these applications had the potential to contribute to an improvement in living conditions, particularly in developing countries.

C. Participants

9. Developing countries were invited to nominate candidates to participate in the Symposium. Participants from those countries held positions in institutions or private industry dealing with resource management, protection of the environment, communications, remote sensing systems, industrial and technological development and other fields related to the themes of the Symposium. The participants were also selected on the basis of their work experience with programmes, projects and enterprises in which space technology was already used or was intended to be used.

10. Policy makers and others at decision-making levels from national and international entities were also invited. They were asked to highlight in their presentations the key issues related to placing a higher priority on the operational implementation of space applications.

11. Funds allocated by the Government of Austria and ESA were used to cover the travel and daily expenses of participants from developing countries.

12. The following Member States were represented at the Symposium: Azerbaijan, Bangladesh, Brazil, Cameroon, Costa Rica, Bolivia, China, Egypt, Ethiopia, India, Indonesia, Iran (Islamic Republic of), Kenya, Malaysia, Mongolia, Nigeria, Pakistan, Romania, Sri Lanka, Syrian Arab Republic, Thailand, United Republic of Tanzania, Uruguay, Uzbekistan, Viet Nam and Zambia. The following international organizations and national entities were represented: Office for Outer Space Affairs of the Secretariat, European Commission, ESA, International Space University (ISU); Austrian Space Agency (ASA), Brazilian Space Agency (AEB), Indian Space Research Organization (ISRO), Instituto Nacional de Técnica Aeroespacial of Spain, National Remote Sensing Centre of China and PT. Telekomunikasi Indonesia. The space industry was represented by participants from Aerospatiale (France), Daimler-Benz Aerospace (DASA) (Germany), Gesellschaft für angewandte Fernerkundung (Germany), GISAT (Czech Republic), Resource 21 (United States of America), Satellite pour l'observation de la terre (SPOT) Image (France), Surrey Satellite Technology Ltd. (United Kingdom of Great Britain and Northern Ireland), United States Global Positioning System Industry Council and the World Space Foundation (United States).

I. PRESENTATIONS AND DISCUSSIONS DURING THE SYMPOSIUM

13. While there had been a slight decline of expenditures in many government civil space programmes, there was a clear trend towards an increasing growth in civilian space expenditures from commercial firms and from smaller countries.[3] The year 1996 was the first to record commercial revenues that surpassed government expenditures. According to a recent study, worldwide space industry revenues in 1996 approached 77 billion United States dollars ($) and employment was greater than 800,000.

14. Space industry encompassed a broad range of activities that could be roughly divided into four sectors: infrastructure, telecommunications, emerging applications and support services. Because of its scope and size, telecommunications was considered a separate sector, while other applications such as remote sensing and navigation services, from a commercial point of view, were still being treated as emerging applications.

15. In this emerging market place, developing countries had become significant purchasers of space-related products and services and represented an important customer base for the space industry. It was essential, however, that developing countries increased their indigenous capabilities to participate in this market not only as customers, but also as potential sellers of space technology and service providers.

16. Only a few developing countries had the resources to engage in full-fledged space programmes. Space technology had the potential to offer benefits suiting many specific needs, and seeking mutually beneficial forms of cooperation with industry was one way to address those needs.

17. The keynote address of the Symposium provided some valuable insights into the Indian experience, which was based on the vision that the effective use of technological advances was indispensable if the challenges and demands of an exponentially growing population were to be met. Such a vision made it imperative for India to adopt an application-driven space programme.

18. In the early 1970s, the situation of India was typical of that of any developing country. There was a lack of adequate industry infrastructure and capacity to satisfy the quality demands of a space programme. Thus, from the beginning, priority was given to promoting a close relationship with the industry to develop the required capabilities.

19. Initial space activities were carried out solely by the Government. Subsequent phases involved technology transfer from the space agency to industry, with buy-back guarantees for the products. Once industry had matured to a certain degree, development was carried out by industry with partial research and development (R & D) support from the Government. Several academic institutions were also involved in the research activities. Currently, about 45 per cent of the budget of the Indian Space Department flowed to the Indian industrial sector.

20. Most industries had benefited from this association by improving their own quality standards. The companies were generally among the first to obtain ISO 9000 certification of the International Organization for Standardization (ISO). Cooperation also resulted in the training and education of highly qualified employees.

21. Following the successful launches of remote sensing and communications satellites, ISRO entered the operational phase in providing space-based services for a variety of applications. A commercial venture called ANTRIX Corporation Limited was established and was making significant inroads on the international scene through the forging of global partnerships.

22. The Indian space centres were providing scientists and engineers from other developing countries with training under the sharing of experience in the space fellowship programme (SHARES). This was seen as a contribution towards future partnerships as the Indian experience taught that collaboration between developing and developed countries could lead to synergy, thus benefiting all partners.

23. A representative of Aerospatiale outlined opportunities for cooperation, noting that for the space industry, a key issue was cooperation with developing countries. However, the space industry had little influence in defining an independent policy towards developing countries; its business strategy must be within the framework of a national space policy generally defined by its national space agency. As space was still seen as a high-technology venture, cooperation policies had to be approved by Governments. In addition to the national space agencies, international organizations and national ministries of cooperation might provide financial aid. Cooperation might be direct or through indirect relations promoted by international organizations such as the European Organization for the Exploitation of Meteorological Satellites (EUMETSAT), the European Telecommunications Satellite Organization (EUTELSAT), the International Mobile Satellite Organization (Inmarsat) and the International Telecommunications Satellite Organization (INTELSAT).

24. From a space industry point of view, developing countries also needed to be classified with respect to their position in the space arena. In this context, it was often more appropriate to use the concept of purchasing power capacity (PPC) instead of the gross national product (GNP). Emerging space countries like Brazil, China and India, with a high PPC, already had developed strong ties with space industries in other countries. The industry should therefore concentrate on those countries that had not yet begun to use space technology applications.

25. There were two primary axes for industrial cooperation: the building of space industry through technology transfer, with the creation of a technical capability in the country, or the creation of national capabilities in application niches with the aim of becoming a specialized service provider to space industry.

26. The first axis covered mainly the satellite and launcher business and could be conducted following a phased approach. A country could start with sounding balloons, which could provide a payload technology capacity as well as knowledge of meteorology and upper-atmosphere science at a cost of approximately $1 million and taking three to five years to completion. The next step would include the development of microsatellites (weighing less than 100 kilograms) to create a local education base. The cost for such an endeavour was about $10 million and the typical project duration was two to five years. For industries that already had gained some experience in satellite development, there was the possibility of licensing whole multimission platforms and acting as a provider of complete systems. Other possibilities included the development of ground facilities for satellite testing or control and satellite payload development for scientific or application-oriented satellites, both of which could lead to viable commercial perspectives.

27. Cooperation in the launcher business was more difficult to establish. Not only was a considerable amount of investment required, but a country might also have to face restrictions in acquiring certain technologies. The favourable geographical location of many countries would provide excellent conditions for establishing a launch infrastructure. However, it had to be considered that the development of sounding rockets or small launchers with solid propulsion would cost at least $150 million to $200 million, with a minimum development time of 5 to 10 years.

28. Those countries that did not intend or cannot afford to engage in full-scale development of a satellite or launcher could enter via the space service segment, which could be described as the link between the space object and the users. Space services encompassed a multibillion dollar market with a projected growth rate by a factor of three over the next eight years. The relatively low entrance fee and the payback that could be expected for the national economy made the space service business highly relevant for developing space countries. Business opportunities could be found in offering services for data access for multinational projects, transponder leasing, ground stations, participation in regional satellite systems and through the development of skills in specific application niches. Without doubt the biggest problem was in sustaining the political and industrial willingness with a sufficient level of investment over many years to ensure the successful outcome of the project.

29. ESA has over 20 years of experience in cooperation with developing countries in basic sciences, telecommunications and Earth observation. The most effective areas of cooperation were education, technical assistance, the provision of hardware and software tools, the provision of data, meetings and the distribution of information.

30. From a space agency point of view, several issues needed to be considered when engaging in cooperation, including budget adequacy, institutional support and the availability of skilled people and proper infrastructure. Above all, rentability and continuity were the two key factors.

31. Cooperation within an international framework could help begin an activity or obtain better internal support, which could unblock a difficult internal situation and complement technical and material resources.

For example, space agencies in cooperation with industry could help demonstrate to decision makers the cost effectiveness of using remote sensing data so that its use as a planning and management tool would be included in future budgets. Industry in the form of value added companies (VAC) acted as an intermediary between the raw data products delivered by space agencies and the information required by the users. As a result of those activities, the number and skill of VACs was growing in Asia and also recently in Latin America.

32. There were evident advantages in cooperation on the technical side, through the higher skill acquired by the personnel involved, on the financial side, through the long-term savings made throughout all phases of a given project, and on the managerial side, through the education of decision makers and project managers.

33. ESA itself was initiating occasions for cooperative ventures between companies of developing and developed countries, stimulating business opportunities and provoking and facilitating the transfer of know-how. A major area of cooperation was projects related to disaster monitoring and mitigation where both telecommunications and remote sensing from space could provide essential and cheap tools.

34. There was still a large gap between the potential and the actual use of space technology. ESA recommended implementing a realistic strategy for cooperation between developed countries, space agencies and companies from developing countries, possibly within the framework of programmes of international organizations. Such a strategy would contribute to reducing the gap between developing countries and the industrialized world, and space agencies, international organizations and more developed countries would see their efforts put to better use in a much larger part of the world.

A. Space industry cooperation and technology exchange

35. The presentations were focused on the issues of technology exchange and, specifically, the microsatellites industry which currently offered realistic prospects for developing countries to gain hands-on experience with space technology.

36. DASA presented its experiences of cooperation with Argentina, China, India and Israel, which involved full technology transfers. The experience of DASA had been that emerging space countries focused on telecommunications, Earth observation and launcher development, which provided a basis for autonomy in space exploitation. All those applications had operational as well as commercial potential.

37. The cooperation between the Chinese Aerospace Corporation and DASA resulted in the creation, in 1994, of a joint-venture company named EurasSpace. Its goal was to jointly develop and market satellites for communications and Earth observation applications for the Chinese and other markets. Another successful example was the cooperation with ANTRIX, the commercial arm of ISRO. In the early stages of cooperation, DASA was providing hardware; it had now begun to procure equipment and satellite components from India. DASA was also involved in the development of the AMOS satellite with Israel and the Nahuel satellite with Argentina. All those ventures had been based on the principle of "Today's partners are tomorrow's partners". Even though emerging space countries had limited resources, together they represented a large market and a driving force for space exploitation.

38. Spain recently launched its Minisat 01 satellite, a low-Earth-Orbit (LEO) spacecraft in the 200-kilogram class, with a scientific mission. The successful operation of the satellite opened opportunities for future application missions. Even for a country like Spain, such an endeavour would not have been possible a few years ago. But with technology facilitating the construction of small satellites, access to space had now become a reality for small- and medium-sized countries. Cooperation with ESA and other international programmes had provided the know-how, methods, procedures and industrial background required for the development of Minisat 01.

39. Small satellites (at a price of $16 million to $19 million) were less costly, decreased the probability of cost overruns, shortened time scales for development and were ideal candidates for the development of domestic capacities and international cooperation. The Government of Spain had expressed interest in cooperating with other countries for the development of future missions.

40. As one of the prime developers of microsatellite technology, Surrey Satellite Technology Ltd. and the Centre for Satellite Engineering Research at the University of Surrey had developed a satellite technology transfer and training programme which involved the design, building and operation of complete satellites. Technology transfer had already taken place between Surrey, Chile, Malaysia, Portugal, Republic of Korea, Singapore, South Africa and Thailand. About 70 engineers had been trained as part of the technology transfer training programme.

41. Advances in microelectronics had made small-scale space missions very affordable. This development enabled any country, or even universities, to build, launch and operate its own satellite. Although microsatellites were physically small, they were still complex and had all the characteristics and complexities of a large satellite. Low-cost, rapid timescales and manageable proportions made this very attractive for emerging space countries that wished to establish their national expertise by taking a low-cost and minimum-risk approach, which could lead to a space programme evolving over a time period of 5 to 10 years from the development of a 50-kilogram microsatellite to a 400-kilogram-class minisatellite to a fully sized 1,000-kilogram satellite.

42. AEB cooperation with private industry was outlined as an example of a national space policy including interaction with private ventures. As part of its industrial policy, AEB gave incentives to companies investing in research and development of technology relevant to the space programme of the country. AEB experience in cooperation with other countries and industries had been helped by a defined national space policy that also addressed the financial aspects.

43. Starting with its initial stages, the planning for cooperation should consider issues of self-sustenance, the intention to market the final product of the cooperative venture to a third party, the support that big industries or companies can provide to smaller companies and any issues related to technology transfer. In developing countries, the Government might need to be initially proactive and to facilitate industry cooperation and partnerships with developing countries.

B. Satellite systems for domestic communications

44. While the majority of countries were now linked to the global telecommunications infrastructure, a considerable number of regions in the developing world were still without basic domestic communications infrastructures. The advantages and disadvantages of using satellite-based communications systems to alleviate this problem were discussed.

45. The diversity in the telecommunications infrastructure available to countries in the Asia and Pacific region represented one stumbling block for harmonious economic growth in the region. With that background in mind, the preliminary conceptual design of a wideband satellite network—ASIA Sky-Link—was presented. ASIA Sky-Link would deliver wideband access and gigabit digital pipes operating in the Ka-band for the Asia and Pacific region. The system was developed specifically to take into account the urgent needs of developing countries for wideband access, a need that could not be fulfilled by terrestrial systems alone. Although initially only regional in scope, the system could be extended to other regions through the use of inter-satellite links.

46. The cooperative information network linking scientists, educators, professionals and decision makers in Africa (COPINE) was a project aimed at responding to the immediate needs of African countries for information exchange. Initially, it would link urban and rural centres of 12 African countries and selected hospitals,

universities and institutions located in Europe and elsewhere. Although the possibilities for data exchange would be superior to those currently available via the Internet, COPINE could also serve to complement already available Internet services.

47. The COPINE project also envisaged the involvement of the private sector. At least one international telecommunications company had expressed interest in shared investment. To ensure longer-term sustainability, the involvement of local telecommunications companies was seen as important and beneficial. The meeting of the COPINE Provisional Governing Board in December 1997 was to agree on the tasks to be performed and the resources to be made available for the completion of the COPINE preparatory activities.

C. Space systems for tele-education and telehealth applications

48. WorldSpace Inc., a private company, would soon launch its first satellite, which was part of a planned constellation of three satellites providing digital audio broadcasting (DAB) to a worldwide audience of 4.6 billion people living in 130 developing countries.

49. The project was based on the assumption that in rural areas with underdeveloped telecommunications infrastructures, radio was the preferred and most accessible means of distributing and receiving information. The end-user equipment would be solar-powered, addressing the problem that three fourths of the African population was still without a reliable source of electricity, which made it unlikely that the Internet would be available to the general public in a short time. The addition of a small liquid-crystal-display-screen providing visual information would support the distribution of educational programmes.

50. Distance learning was certainly not equivalent to a teacher-led interactive learning dialogue, but it was clearly an improvement on a situation where at least 50 per cent of African children were not in classrooms. The World Space Foundation was seeking to establish contact with educational organizations and national governments that fully understood the cultural milieu in which they worked, in order to develop and deliver programmes addressing critical issues relating to basic education, health, literacy, disaster relief, women and family development, the environment, cultural heritage and vocational training. A conference on distance education was held at Accra in April 1997 and was attended by 14 African Ministers of Education and some 180 education specialists, donors and media representatives. The consensus was that distance education was a credible option for education, an option that needed to be adopted.

51. Though India had one of the largest education infrastructures in the world, the education and training needs of the country were still not met. The large number of illiterates and three million teachers who were often inadequately trained remained a serious problem. Traditional education systems could not keep pace with education requirements. Distance learning was one answer to the problem. Satellites had been used since the 1970s for tele-education purposes. The Indian National Satellite (INSAT) series of satellites provided two-way audio and one-way video capabilities which allowed the students to directly interact with the teachers.

52. The use of satellite links for telehealth applications was demonstrated with the Satellite Health Access for Remote Environment Demonstrator (SHARED) project. SHARED was a pilot platform to support a remote health-care structure and was originally proposed and coordinated by the San Raffaele International Biomedical Science Park in Italy in cooperation with ESA, the Italian Army, Marconi-Alenia and Joanneum Research of Austria. The system was based on the multipoint videoconferences system of the Direct Inter-Establishment Communications Experiment (DICE) which was the primary communications medium for the EUROMIR missions and other human space missions, including the Austrian AUSTROMIR, the German MIR-92 and the French CASSIOPEE missions. The system was used to test new approaches and innovative models allowing access to health care and biomedical services in remote and underdeveloped regions.

53. While satellite-based systems for tele-education and telemedicine applications might initially appear to be rather expensive, a large number of people could be reached quickly and efficiently. The cost of hardware would continue to decrease, the ground systems would become more compact and less cumbersome to use, and more people would benefit from those applications. Given the large number of people that needed to be serviced, they also opened up tremendous opportunities for industry and for partnerships between developed and developing countries.

D. Remote sensing applications: the role of distributors and users

54. SPOT Image was one of the major companies acting as a distributor of remote sensing data and information. The use of remote sensing data was steadily increasing with applications in environmental control, urban planning, agriculture and forestry, geology, public services, mapping and geographic information systems (GIS). Data vendors like SPOT Image had recently experienced a strong growth in revenues.

55. SPOT was trying to enhance the development of integrated solution packages through a number of projects aimed at proving the capability of SPOT satellites and their applicability to specific problems, as well as to expand the application market and to increase SPOT data sales. The projects were carried out in partnership with service providers and VACs. For example, the parties involved in the projects conducted geological studies and a national inventory of natural resources in Madagascar, established a forest inventory in Tunisia, created an agricultural land information system in Egypt and an action plan for flood control in Bangladesh, controlled resettlement of refugees in Cambodia, and prepared a demographic census in Nigeria, a dam site impact study in Cameroon, erosion studies in Chile and a cartographic survey of mine dumps in South Africa. A large number of donors contributed to the success of the projects.

56. New operational satellite data products such as digital elevated maps would be made available to users. VACs were to be promoted and encouraged for catering to user needs more effectively. Clearly, where appropriate, the relationship between donors and developing countries should be closer to ensure that the needs and concerns of all parties involved were better understood. Finally, the market for remote sensing data offered great opportunities for specialists in developing countries to serve certain niche markets and to act as a commercial distributor of value-added remote sensing data.

57. The importance of information derived from remote sensing data was illustrated with applications in disaster monitoring and assessment. In China alone, there was an annual loss of approximately $20 billion because of floods. Remote sensing data integrated into a GIS could be used to help monitor droughts and forest fires and to assess the probability of and possibly predict earthquakes. These applications constituted the basis for a large future commercial market.

58. The European Commission was funding several Earth observation projects in cooperation with developing countries. The projects included the Tropical Ecosystem Environment Observations by Satellite programme, the Fire in Global Resource and Environmental Monitoring programme, the Satellite Assessment of Rice in Indonesia programme, the South East Asia Rice Radar Investigation of the Joint Research Centre of the Commission, as well as several others.

59. The European Commission was also financing the transfer of equipment, technology and know-how (training). Cooperation with developing countries was based on three priorities: the improvement of public health, the improvement of agricultural and agro-industrial production and the sustainable management of renewable natural resources (forests, oceans, water and energy). One reason for its involvement in such projects was certainly also to develop the commercial market for remote sensing applications.

E. Remote sensing applications and value-added services for agricultural monitoring

60. "Precision agriculture" or "precision farming" described a method of agricultural monitoring which included the use of frequently updated information gathered by remote sensing satellites. The aim of the technology was to help maximize agricultural yields in a sustainable manner.

61. Two often expressed concerns of would-be operational users of remotely sensed data would be resolved in the near future. Those concerns related to the frequency of coverage and the dependability of the source. Approximately 31 land observation satellites were planned to be launched by the year 2000. The frequency of coverage would increase to several times per week, increasing the range of applications that might benefit from the use of remote sensing data. With regard to dependability, it was very likely that individual needs would soon be met by more than one supplier, thus providing the redundancy for supply continuity.

62. Resource 21, a business partnership involving agricultural and aerospace companies, intended to launch a constellation of four satellites. Their main application would be to provide timely data on crop yield modelling, but they would also serve to monitor natural resources, the environment and national security, and would be used for scientific applications. The gathered information would then be integrated into a GIS environment, for example, a scenario for nitrogen fertilizer management based on sensing and detection of symptoms, diagnosis and remedy.

63. Representatives from GAF/EUROMAP and GISAT presented examples of the use of remote sensing data for agricultural applications in Europe. In that context, the European Commission acted as the largest buyer of remote sensing data in Europe which is used for the control of area-based subsidies.

64. The application demand was an important driving force for the development of space industry and space technology. The demand for more accurate weather predictions resulted in the development of meteorological satellite systems. Similarly, the demand for more accurate data enabling sustainable planning would drive the development of Earth resource and environmental satellites. The development of space industry and space technology in general was accelerating the operationalization of remote sensing applications. Compared to meteorological applications, the monitoring of natural disasters, crop growth conditions, predicted yield and environmental processes such as desertification and urbanization was currently in what could best be described as a pre-operational stage, with mapping applications close to being operational.

65. Operational and commercial aspects, however, did not necessarily go hand in hand and should be considered separate entities. Nevertheless, the benefit derived from remote sensing applications was mostly a social benefit. To become commercial, the economic benefit had to be increased. That was also reflected in the fact that the majority of users of remote sensing data were governmental agencies, while the broad market still required some time to develop.

F. Positioning and localization systems and services

66. Applications based on the Global Positioning System (GPS) increasingly penetrated many facets of everyday life. The GPS market had shown an exponential growth rate from $40 million in 1989 to $460 million in 1993, and was expected to grow to $5 billion to $6 billion by the year 2000. In the meantime, the average cost of hand-held GPS receivers had fallen from $500 to $300, and recently to as low as $150. There was a huge potential market for space-based navigation and localization systems, and new applications were being developed continuously.

67. The United States Global Positioning System Industry Council was an alliance of companies including the original technology innovators, accounting for 60-75 per cent of total United States production. The aim of the

council was to act as an information source for the Government and to promote sound policies for the development of commercial markets and civilian applications, while preserving the military advantages of GPS.

68. The most promising markets included vehicle navigation, the recreation market, agricultural applications such as precision farming and the military market. However, the existing regulatory framework and standards might be inadequate to accommodate such a broad range of GPS applications. New policy perspectives coordinating the commercial, consumer and strategic requirements on a national and international level needed to be established, and the dialogue between military, industry and civilian users needed to be extended. Those coordination activities were essential to maintain open markets and to ensure the global acceptance of GPS. Similar organization in Europe and in other countries on a national and regional basis also needed to be established.

69. One major application of GPS was the integration of GPS data into a GIS to provide information for land, sea and air navigation, cadastral surveying, geodetic network densification, high-precision aircraft positioning, photogrammetry without ground control, monitoring deformation and hydrographic surveys. Other applications involved urban planning, environmental analysis, transportation, watersheds, soils and agriculture, demographics, wildlife and endangered species, public health and emergency management. The development of new GPS applications usually took place in universities, which also provided training. The private sector, however, was responsible for ensuring that GPS applications became a practical and commercial reality.

70. The European Satellite Navigation Programme (ESPN) was being defined in cooperation with industry by the European Commission, ESA and Eurocontrol. A first step in the programme was the development of the European geostationary navigation overlay service, a European regional augmentation to GPS and the Global Orbiting Navigation Satellite System (GLONASS) of the Russian Federation. It would greatly improve the integrity and accuracy of the navigational signal, primarily driven by aeronautical requirements. Currently neither GPS nor GLONASS met civil navigation requirements, and suffered from a lack of civilian control.

G. Wrap-up session

71. The final presentation of the Symposium tried to provide answers to the question, "How can space activities be brought into the economic mainstream?", which had been posed to participants in the Second Annual International Symposium of the International Space University (ISU), focusing on the theme "New space markets", held at Strasbourg, France, in May 1997.

72. Most participants expressed the opinion that the space community needed to build bridges between the technical and the commercial world. While private ventures would increasingly displace Governments from the telecommunications, Earth observation and launch service markets, it was agreed that Governments should continue to pursue "bold, difficult and audacious" programmes. To ensure that market forces satisfied national needs, especially those of developing countries, concerted efforts at all levels, sustained over a long period of time, were necessary, as the Indian example showed. The benefits of space technology applications must be brought into the political and bureaucratic mainstream and into the everyday consciousness of the ultimate end-users. That was the ultimate challenge for the space community.

II. OBSERVATIONS AND CONCLUSIONS

73. The involvement of industry in space activities addressed all space sectors: the space segment (such as satellites, launchers and space balloons), the ground segment (such as facilities, infrastructure and networks), data distribution and applications. It encompassed the lifetime of every project, starting with the feasibility study

and including the preliminary and detailed design, development, implementation, integration, testing, operations, maintenance and upgrading.

74. In the context of the Symposium, most participants were interested in discussing application projects, namely for telecommunications and remote sensing.

75. For any new partnership, two categories of opportunity existed: joining an ongoing project or creating a new one. The value of an application project for possible investment by industry and the development of a market was mostly related to the credibility of the project in leading eventually to the delivery to the final user of an operational system for routine activity.

76. The most productive way to achieve successful involvement of companies from developing countries was to seek joint ventures with industry from more advanced countries, whereby the cooperation would allow the exchange and transfer of know-how through technical application projects.

77. However, many difficulties and sensitive issues had been identified, arising mostly from the wide range and variability of conditions around the world, involving such matters as costs and local laws and regulations (relating to labour, trade and funding), standards, patent rights and intellectual property, local environmental conditions, sociocultural aspects and transient political situations.

78. In the above-mentioned context, international organizations could and should play an important role, by providing both a higher-level institutional framework to cooperative projects and the necessary starting conditions, which often included a limited amount of start-up funding.

79. Numerous comments and remarks were made with respect to the various aspects of possible cooperation initiatives between the three major parties, namely international bodies (such as agencies and banks), industry and national entities.

80. In setting up a project, cooperation must be recognized as a two-way process and needed to be based on an equal and fairly balanced partnership. It required mutual knowledge and respect; frequently, companies from developing countries were forced to act only as agents of firms from industrialized countries, not as parties in a genuine partnership. Technology transfer must enable the receiving country to progress on its own, not to depend on the supplier forever.

81. A strategic vision had to be shared among partners, in order to remove barriers and to make risks affordable just by sharing them. Programmes that grew together and shared risks and rewards were the most productive.

82. Grand projects should be avoided and experience should be sought in small and affordable endeavours. Once selected, they should be carried out without major discussions. Such an approach required imaginative leadership and foresight.

83. Developing countries should start their own national programmes. That was the only way to trigger the market and create conditions for growth and market development, although the timing of investment could be typically compared to the problem of deciding which came first, the chicken or the egg. However, the two components (the chicken and the egg) should be developed together in order to grow together.

84. National programmes should seek to create a market where one did not exist, and industry from developed countries should be prepared to pre-invest in project studies in developing countries in order to bypass the

chicken and egg problem. However, in this case also, the prerequisite was a fair partnership between firms from developed countries and those from developing countries.

85. For the implementation of projects beyond the study phase, the participants noted that a combination of the following considerations should be addressed:

(a) To gain a foothold, industry in developing countries should concentrate on specific industries and develop niche markets, in order to acquire, as far as possible, specialized skills without dispersing resources;

(b) Industry should be encouraged to advise on how to proceed, since industry would not participate in something that did not hold out the prospect of financial benefit;

(c) The involvement of major industries would often mean opening possibilities for numerous small companies working downstream and acting as parts or service suppliers;

(d) Regional or global projects, such as regional thematic initiatives, generally had good prospects of being funded by Governments and international bodies, thus presenting opportunities for local industry to perform a part of the task on a commercial basis;

(e) Companies and agencies in developing and developed countries should actively seek opportunities to meet and open the way for cooperative ventures;

(f) Technology transfer meant increasing the knowledge of people, and hence training and hands-on activities;

(g) Creating a market meant educating the users, which could in turn lead to very interesting opportunities.

86. Issues specifically relating to the responsibilities and roles of senior management in institutions and policy makers in Governments were as follows:

(a) Ensuring that long-term commitments would be honoured;

(b) The limitation and alleviation of regulations concerning technology transfer;

(c) The possibility of promoting exports, based on some initial elements of technology, and starting local production with national funding;

(d) The use of fair pricing policies.

87. The actual strengths of the developing countries should be fairly recognized as appropriate, and criteria for partnership selection should be technical and financial only.

88. Because of the commercial trend in the development of the telecommunications market and, at the same time, the need for continuing investment in scientific programmes endorsed by the Government, a national space plan should aim at developing scientific applications and at deregulating the telecommunications market as a commercial activity. In both areas, commitments with other countries were required to make the system work.

89. International organizations might provide very important support, not only in financial terms, but also in arranging opportunities to meet and advise on building cooperative endeavours.

90. Managers and policy makers in developing countries often proposed measures to be taken nationally, but national priorities in most cases did not allow funds to be made available. International agencies could help by providing a small part of the funds (for example, 2 per cent) required to encourage national investment and allow progress to be made.

91. A proposal had been made for the creation of a specific international body that would screen, develop and provide some sort of technical and political support to space projects, by fostering cooperation among the three main actors: international entities, industry and national authorities.

92. Similarly, international bodies had been urged to encourage cooperation with regional space organizations, in particular those serving African and Arab countries, with the aim of providing international support to foster regional cooperation and stimulate efficiency and effectiveness.

93. When referring to developing countries in the context of space technology applications, a distinction should be made between emerging space countries and countries that had not yet started or were not yet involved in any space programmes, but wished to do so. Since the level of development varied enormously from one developing country to another, cooperation with developing countries should also be varied to meet their specific needs.

94. Governments that became aware of the benefits to be derived from space technology applications were more likely to find ways to remove bureaucratic bottlenecks that impeded international cooperation and commercial ventures. Some participants in decision-making positions noted that it would be useful to make available a document outlining the advantages of, and the necessary working procedures for, the utilization of space technology applications tailored to the needs of developing countries at various levels of development.

Notes

[1]See *Report of the Second United Nations Conference on the Exploration and Peaceful Uses of Outer Space, Vienna, 9-21 August 1982* (A/CONF.101/10 and Corr.1 and 2), para. 430.

[2]*Official Records of the General Assembly, Fifty-first Session, Supplement No. 20* (A/51/20), para. 37.

[3]George Ojalehto and Henry Hertzfeld, "Space spending balance shifts in 1996", *Aerospace America*, July 1997.

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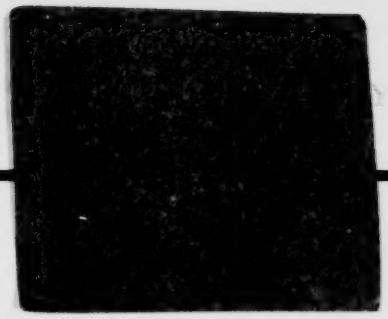

REPORT OF THE UNITED NATIONS WORKSHOP ON SPACE COMMUNICATIONS TECHNOLOGY FOR CAPACITY BUILDING, ORGANIZED IN COOPERATION WITH AND HOSTED BY THE GOVERNMENT OF ISRAEL

(Haifa, Israel, 21-25 September 1997)

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INTRODUCTION

A. Background and objectives

1. On 10 December 1982, the General Assembly adopted resolution 37/90, in which it endorsed the recommendations[1] of the Second United Nations Conference on the Exploration and Peaceful Uses of Outer Space. In that resolution, the Assembly decided, among other things, that the United Nations Programme on Space Applications should disseminate, through panel meetings and seminars, information on new and advanced technology and applications, with emphasis on their relevance and implications for developing countries.

2. The United Nations Workshop on Space Communications Technology for Capacity Building was one of the activities of the Programme for 1997 that was endorsed by the General Assembly in its resolution 51/123. The Workshop was organized in cooperation with the Government of Israel, and was hosted on that Government's behalf by the S. Neaman Institute. It took place from 21 to 25 September 1997, the participants coming from both developed and developing countries.

3. The objectives of the Workshop were to give the participants, particularly the managers of telecommunication institutions, the opportunity to explore ways of using space communication technology to further the development of their respective telecommunication infrastructure, and to consider ways in which developing countries could use satellite communications and broadcasting to become a part of the global information society.

4. Presentations were made at the Workshop on the use of global satellite broadband communications systems, stratospheric high-altitude long endurance platforms, direct-to-home (DTH) satellite broadcasting, very small aperture terminal (VSAT) systems, low Earth orbit (LEO) non-voice messaging systems, frequency spectrum regulations and usage, optical satellite communications, satellite-based disaster warning broadcasting and spacecraft on-board technology, and how they could be used, separately or collectively, to improve existing telecommunication infrastructures and provide both basic telephony in rural regions and value-added services in areas with a high-density population.

5. The present report, which covers the background, objectives and organization of the Workshop, the observations and recommendations made by the participants, as well as a summary of the lectures presented, has been prepared for the Committee on the Peaceful Uses of Outer Space and its Scientific and Technical Subcommittee. The participants will report to the appropriate authorities in their own countries.

B. Organization and programme of the Workshop

6. The Workshop was attended by 72 participants from 19 States Members of the United Nations, including the following: Belarus, Cameroon, Czech Republic, Cyprus, Estonia, Hungary, Latvia, Lithuania, Nigeria, Poland, Romania, South Africa, Viet Nam and Ukraine. Speakers at the Workshop came from France, Israel, Italy, Russian Federation and the United States of America. The Office for Outer Space Affairs of the United Nations Secretariat, the International Telecommunication Union (ITU) and the International System and Organization of Space Communication (Intersputnik) were also represented.

7. The participants were professionals with several years of experience in managerial positions with national telecommunications institutions and companies.

8. Funds allocated by the United Nations were used to defray the cost of air travel and an allowance for incidental expenses of 13 participants from 13 countries. The Government of Israel, through the S. Neaman Institute, provided room and board for those participants.

9. The programme for the Workshop was developed jointly by the Office for Outer Space Affairs and the S. Neaman Institute. The Workshop was conducted through a number of plenary and working group meetings. At the latter, the participants discussed issues related to the use of space communications technologies to improve telecommunication infrastructures and concluded the meetings with the observations and recommendations presented below.

I. OBSERVATIONS AND RECOMMENDATIONS OF THE WORKSHOP

A. Observations of the Workshop

10. Participants observed that in areas with an undeveloped telecommunication infrastructure, wireless local loop (WLL) technologies were making a forceful entry as a low-cost solution to the "last mile" problem. Such areas currently had a population of more than 3 billion people. The only reasonable way to penetrate that market was to exploit land wireless and satellite wireless technologies together.

11. It was increasingly unrealistic to expect developing countries with large, sparsely populated areas to build an infrastructure with wireline technologies. Instead, it was more likely that the isolated high-density population areas of the country would be connected via wireless and satellite links.

12. There was considerable interest in creating new global satellite systems to offer communication services to parts of the world that were currently underserved, and to exploit the anticipated growth in demand for data distribution arising from the computer-to-computer distribution of multimedia. The cost of building all of those systems probably exceeded the amount of risk capital, so that only a few were likely to be built.

13. By the end of 1996, nearly 2,200 space networks, notified by 62 administrations (including international satellite organizations), had been in one of the phases of processing by ITU.

14. The satellite fraction of telecommunication revenues, as commonly estimated, was less than 3 per cent of the current market in global telecommunication infrastructures; that figure was likely to amount to somewhere between 5 and 10 per cent in the future. Associated with wireless technologies, satellite communications could play a major role in global communication infrastructures.

15. The most important development in satellite communication mission design within the last decade had been the use of new orbital configurations to create improved look angles, increase irradiated power densities, achieve different coverage patterns, reduce signal transmission latency, and allow operation with hand-held terminals.

16. In addition to the financing of new communication systems, there were technical challenges to be overcome. They included the building of satellites, which for the first time employed large, complicated on-board processors, and reduction of the cost of the earth terminals to affordable levels. The Ka-band rain fade problem would be severe in some parts of the world, and might limit the types of service that would be acceptable to users. Already some proponents were known to be rethinking mission scenario designs of their communication systems with a view to achieving a lower-cost entry into the market. It was also likely that some of the project proposals would merge as an additional way of reducing the business risk.

17. Several key satellite technologies were still being developed. There was no on-board processor that could handle all of the switching and routing of the thousands of calls in milliseconds. There was currently no reasonably priced active-phased antenna system with electronic beam forming and tracking. Finally, there were

no flight-proven and reliable automatic satellites or high-altitude long-endurance platforms that could cost-effectively support those operations.

18. Conservative estimates suggested that mobile satellite systems with projected communication rates of $1.00-$3.00 per minute would capture no more than 3 per cent of the total wireless mobile revenues. The most optimistic projections estimated penetration rates that were from three to five times greater. Since those systems would not be largely deployed until the turn of the century, the actual market results would not be known for some time. The key issue was the degree to which consumers other than a small group of international business people would be willing to pay a high premium for global connectivity from any remote location.

19. Developing countries were concerned that the majority of their citizens might not be able to afford mobile satellite services. On the other hand, those services should be an essential element in early warning, preparedness and disaster relief activities and should provide communication links during emergencies. Mobile satellite services would seem to be the most effective in disaster relief, since they were the most resistant to the effects of disasters.

20. Currently, nations could monitor or intercept telephone transmissions within their countries. A major concern of national regulators was whether satellite mobile services could allow law enforcement personnel to continue to monitor calls.

21. In accordance with the ITU Radio Regulations, the advance publication procedure was the obligatory first phase of the relevant regulatory process. It did not give the notifying administration any rights or priorities. The coordination procedure was a formal regulatory obligation both for an administration seeking coordination and for an administration whose existing or planned services might be affected by new assignments. Coordination must be completed before the frequency assignments in question were brought into use or notified to the Radiocommunication Bureau.

B. Recommendations of the Workshop

22. Participants recommended that, because of the ever-increasing use of the orbit/spectrum resources and the resulting likelihood of satellite congestion in the geostationary orbit, more serious consideration should be given at the World Radio Conference 1997 to the question of equitable access to and efficient use of the orbit/spectrum resources.

23. In order to facilitate the implementation of global satellite communication systems, international cooperation, both between industrialized and developing countries and among developing countries, needed to be improved.

24. Satellite communication pricing policies were also in need of improvement. Both local service providers in the countries themselves and ITU on a world scale should be encouraged to seek more liberal approaches to setting up pricing structures.

25. Developing countries should give high priority to telemedicine and distance education applications (with special emphasis on their use in remote and rural areas of these countries), which could be provided at affordable prices by forthcoming broadband satellite communication systems.

26. Participants noted that WorldSpace Inc. was developing, specifically for the developing countries, the first world satellite-based digital audio broadcasting system. Probably, however, most people in developing countries would not be able to afford the quoted price of $200 for a digital radio ("Starman") receiver. It was therefore recommended that every effort should be made to reduce the cost of the Starman radio set. It was also noted that

the radio could apparently be modified at a reasonable cost so as to add a built-in disaster warning feature, and a recommendation along those lines was made to a representative of WorldSpace Inc.

II. SUMMARY OF THE PRESENTATIONS

A. Satellite communications and broadcasting for development

27. Over the next decade, the worldwide telecommunication industry and the information industry in general would undergo massive changes. Privatization of the governmental telecommunication sector and legislation deregulation were a driving force in the development and restructuring of the industry's infrastructure.

28. The information industry had traditionally been defined in terms of the "form" of information involved and the underlying technologies for handling each form, including images, text, voice, data, audio and video. Each must perform a series of functions, including creation, distribution, process, storage and display, in order to serve its markets.

29. The primary impetus for the convergence of those different forms of information was clearly technological change, and the key technological change had been the rapid diffusion of digital technology into an ever-wider array of information businesses. Beyond digitization, dramatic changes in the computing and telecommunication industries were also a force behind such convergence.

30. Digital technology also promised to bring even greater changes, which would be continuous, and which would open up virtually every household to interactive multimedia and video information: through the air from satellites and terrestrial wireless systems, through fibre-optic cables and cable television, and even through telephone company coaxial cables.

31. The growth rate of communication infrastructure and services had been exponential, fed by the commercial economic forces that had followed the deregulation process in many countries. Such activity, however, threatened to widen the gap between the industrialized and underdeveloped countries, a development that was undesirable for either side.

32. Access to a cheap bandwidth would be an essential factor in economic development in the next century, just as inexpensive power was for the Industrial Revolution. Developing countries must be assured of ample, low-cost access to high-density broadband telecommunication links.

33. It was estimated that it would take about 25 years to implement that challenging task by terrestrial means and that it would cost at least $1 trillion to connect the world with fibre optics. Other estimates indicated that the total cost of just closing the telecommunication gap in developing countries would be $3 trillion. Less than one fifth of the world's land surface was currently wired for communication services. Even though there were many fibre-optic networks in the world, and their numbers were growing by the day, they were used primarily to connect countries and the central offices of telephone companies with high-density traffic through trunk lines. Connecting fibre cables to individual offices and households accounted for 80 per cent of the cost of a network.

34. New satellite communication technology could intervene in those cases in rural, low-density traffic areas. Rural customers currently cost between 10 and 30 times as much to serve with wire-based telephone service as urban customers. Developing countries had only 1-3 per cent of the world's telephones and 10 per cent of the television sets. Some 3 billion people, about half of the world's population, lived in countries with less than one telephone line per 100 inhabitants. Recent research had indicated that wireless systems were the most cost-effective way in which to develop or upgrade telecommunication networks in areas where density was

lower than 200 subscribers per square kilometre. Fixed wireless systems could be installed from five to ten times faster than wireline networks, which required considerable investment in infrastructure.

35. Satellites had demonstrated the ability to provide communication services to the less developed part of the globe with astounding ease. They were ideally suited for disaster emergency, relief and development work because they operated independently of the local telecommunication infrastructure. Disasters such as drought and insect infestations currently resulted in annual losses of over $50 billion. The known costs of satellite systems were only a fraction of that figure.

36. Satellite communication was the key technology in the developing countries' participation in the build-up of a global information infrastructure (GII). While developing countries did not constitute a viable market for most of the large-scale satellite communication projects, they benefited from lucrative markets in the industrialized countries that lured international commercial programmes, and might be able to take advantage of the excess capacity of those programmes to satisfy their own communication needs.

37. Satellite communication services and the telecommunication industry were entering a new era, driven by a combination of market growth, liberalization and deregulation of laws that had unleashed commercial economic forces and technological advances, many of which were spin-offs from military developments. The development of the industry still required due care: the large footprints of the satellites limited the density of communications that could be supported without interference. They were liable to mask scientific observations that were just as important to the world economy (weather observations, for example) and research (radio astronomy). A careful balance of interests—communications for everybody, economy, national interests and scientific needs, had to be developed and preserved throughout the process, to guarantee true progress.

38. Currently, international, regional, and domestic satellite systems were predominately "fixed services" (that is, non-mobile earth stations). Those satellites accounted for 90 per cent of the commercial systems in operation, and almost all of them operated in the C-band (6/4 GHz) and the Ku-band (14/12 GHz). The 30-year trend in fixed satellite service (FSS) had been one in which communication satellites were becoming more powerful, were three-axis stabilized, and were using higher-gain and larger-aperture antennas operating with multi-beams to achieve multiple frequency re-use. Those trends not only let satellites increase capacities and lifetimes but also made operation possible with much smaller and cheaper ground stations. The remarkably rapid growth in FSS satellite technology had been paced by competition from fibre-optic cables and the rapidly growing demand for international telecommunication traffic and all forms of television relay. The desire to decentralize Earth-station facilities and reduce their costs had also been a key force in the market place.

39. The world market for satellite communications was distributed among the space segment (satellites, launchers, insurance, control stations), ground segment (end-user terminals and networks), and the services provided. With the expansion of direct-to-home (DTH) television and digital audio broadcasting (DAB) services, and the introduction of personal communication and multimedia services, the ground segment would grow by many millions of users per year, and its worldwide market would amount to nearly twice that of the space segment. But the service segment would account for by far the largest gain. The total market for the coming 10-year period could be estimated at $60-80 billion for the space segment, $120-150 billion for the ground segment and over $400 billion for services. That would amount to a global market for satellite communications of over $600 billion.

40. More satellites were expected to be launched in the next 10 years than all of those put into orbit the past 30 years. Nearly 800 of the projected 1,138 satellites over the next 10 years would be for mobile systems. During the past five years, the worldwide growth rates for mobile telephony had hovered around an astonishing 50 per cent per annum, and some countries were actually doubling their mobile subscriber base every year.

41. Systems using constellations of LEO or medium Earth orbit (MEO) satellites would soon provide personal communication services (PCS). LEO constellations, as well as constellations of geostationary satellites, would provide multimedia services, with fast Internet access, in the very early years of the next decade.

42. There was indeed a very big market for DTH and direct broadcasting services (DBS), very small aperture terminals (VSAT), personal computer (PC), multimedia and other services; but whether all planned systems would prove successful, and the current expansion would continue remained an open question. Serious consideration had also been given to the use of DBS not only for entertainment services but also as a broadband telecommunication interface into the home to support Internet mosaic video services, as well as other broadband services.

43. Satellite communication systems had evolved rapidly from a purely network-oriented approach, interconnecting gateways of different terrestrial networks, to increasingly user-oriented ones, providing services directly to terminals installed on the user's premises. That inevitable evolution resulted from the rapid expansion of fibre-optic cables, which were more appropriate than satellites for trunk telephony and point-to-point communications. The satellites' specific features, namely large coverage areas and instant access to them from any site within those areas, led services to concentrate on taking advantage of those features.

44. The current expansion of satellite systems affected both those based on geostationary satellites and those based on constellations of LEO and MEO satellites. The expansion was supported by many factors: (a) the worldwide growth of the economy, in particular in the Asia and Pacific region; (b) increased demand for direct services to end-users; (c) worldwide expansion of terrestrial cellular services, but with limited coverage; (d) poor terrestrial infrastructures in many areas, both in developing and industrialized countries; (e) worldwide deregulation and privatization of domestic, regional and global telecommunications; (f) intense competition inside the space and the telecommunication industries: many satellite manufacturers had also become systems promoters and operators; and (g) access to considerable private funds for new satellite systems.

45. The expansion of satellite communication systems implied continuous and rapid progress in space technologies and shorter production cycles of satellites and launchers, but the significantly increased difficulties in frequency coordination had to be solved. Many satellite systems required considerable amounts of private investment in the space and Earth segments.

46. That evolution was also accelerated by the rapid progress in satellite technologies (and launch vehicle performances), allowing marked increases in spacecraft mass and power consumption, leading to higher effective isotropic irradiated power for on-board antennas and reduced overall dimensions and cost of earth terminals. The number of those terminals increased considerably with the expansion of DTH Ku-band television services, which became the major users of satellite capacity. The growing expansion of DTH services and the coming introduction of satellite-provided PC and multimedia services would also significantly increase the number of terminals.

47. Digitization of satellite transmissions followed that of the terrestrial ones. Coordination difficulties and system economy compelled satellite systems to use more spectrum-efficient transmission techniques, multiple frequency re-use, more sophisticated antennas, new frequency bands and, if possible, more interference-resistant transmissions. Increased spectrum efficiency was achieved by using digital transmissions with sophisticated coding techniques. For example, in telephony, the 500-700 voice channels (half duplex) capacity of a 36 MHz transponder when using analogue transmissions, increased to 3,600-4,000 channels when using digital ones, and the amount would probably double in the next decade. In television, a 27-36 MHz transponder transmitting one analogue television programme was capable of transmitting from 4 to 12 television programmes when using digital compression. Again, significantly higher compression rates for television signals would probably be introduced in the next decade.

B. New global satellite and stratospheric communication systems

48. It had become extremely difficult to secure an orbital location along the geostationary arc and operate in the C-band or Ku-band without interfering with traffic on adjacent satellites. While additional frequency assignments for commercial satellite use had existed in the Ka-band (roughly wavelengths in the 1.5 to 1 cm range), they had not hitherto been considered because rain absorbed those wavelengths, and little in the way of earth terminal equipment was available for that band.

49. The new proposed satellite (operating in the Ka-band) and stratospheric (operating in the V-band) systems would accelerate the realization of both national and global information infrastructures (NII/GII), particularly in regions of the world where terrestrial telecommunication infrastructures were non-existent or inadequate for high-speed communications. The term "Ka-band satellite" had become generally recognized as a shorthand term for a new generation of communications satellites that would use on-board processing and switching to provide full two-way services to and from small Earth stations comparable in size to the current satellite television dish. Such Ka-band satellite systems had also been described in other terms, such as "multimedia satellites", "Asynchronous Transfer Mode (ATM) satellites", "broadband switched satellites", and "broadband interactive satellites".

50. Proposed services included voice, data, video, imaging, video teleconferencing, interactive video, television broadcast, multimedia, global Internet, messaging and trunking. A wide range of applications were planned through those services, including distance learning, corporate training, collaborative work-groups, telecommuting, telemedicine, wireless backbone interconnection (that is, wireless Local Area Network-Wide Area Network), video distribution, DTH video and satellite newsgathering, as well as the distribution of software, music, scientific data and global financial and weather information. Satellite-based systems were also indispensable for emergency communication services.

51. According to ITU recommendations, those services had been classified into five categories: (a) messaging (electronic mailbox, paging); (b) retrieval (videotext, document retrieval, high-resolution image retrieval, data retrieval); (c) conversational (broadband person-to-person telephony, broadband multipoint videoconference, video surveillance, multiple-sound program signals, high-speed unrestricted digital information transmission, file transfer, high-speed tele-action, telefax, high-resolution image retrieval, document communication, digital telephony etc); (d) user-controlled distribution (restricted digital information transmission, videography); and (e) interactive diffusion (message diffusion, voice and sound diffusion, document diffusion, unrestricted digital information transmission).

52. The Ka-band concept offered the equivalent of a local telephone circuit, where the user paid for temporary lease of time. The Ka-band environment also made it feasible to offer the alternative of charging per bit of information moved. Such services required a lot of bandwidth, however, because each link would usually be operating on a point-to-point basis. The prime method of efficiently using the available spectrum efficiently was to use multiple "pencil" spot beams, each covering only a small area of Earth. That allowed frequency re-use in much the same way as a cellular phone network re-used the spectrum.

53. The use of multiple spot beams in itself demanded the use of on-board processing and switching to direct each transmission path between the different spot beams used for uplinking and downlinking. Similarly, intersatellite links with similar Ka-band satellites would demand switching capabilities. In effect, the on-board processing and switching capability was a network management facility and Ka-band satellite operators would each become like telephone companies but with their telephone exchanges in the sky.

54. The proposed Ka-band systems featured user data rates ranging from 16 Kbps to as high as 1 Gbps, support for ATM, regional and global coverage through intersatellite links (ISLs), a large number of small spot beams,

and the use of on-board baseband processing and switching for beam interconnection. Some of the proposed systems were aimed at providing complete or nearly complete global coverage.

55. The Ka-band available to satellite operators involved a massive 2.5-3.5 GHz of spectrum, some four-seven times that available to some C-band satellite operators. In 1997 some 59 Ka-band projects had emerged worldwide, alongside an intensified research and development (R&D) effort to refine Ka-band satellite and associated technologies.

56. The development of those systems was contingent upon overcoming significant challenges in terms of frequency coordination, technology readiness and financing. That meant that only a few of the proposed systems could be expected to be deployed by 2000 or 2005.

57. The proposed Ka-band systems used a large number of small beams (approximately 1 degree) to deliver a high satellite effective isotropic radiated power (EIRP) of 50 dBW to user terminals. Beam types and their quantities varied widely from one system to another. Hopping beams (proposed by some systems) provided efficient satellite resource utilization by assigning each beam to a number of dwell areas (beam spots) consisting of one major traffic area and several thin-traffic areas. Dwell time could be adjusted dynamically on the basis of response to the traffic demand of each beam area.

58. Fixed-beam satellites were generally simpler in design than hopping-beam satellites. For an efficient use of resources, however, coverage areas needed to be adjusted to place roughly equal amounts of traffic into each beam. The number of fixed beams per satellite could be anything from 10 upwards.

59. Most of the systems proposed would employ on-board baseband processing and switching. The on-board processing subsystems would use fast packet switching, which was also referred to as "cell switching", "packet switching", "ATM switching", and "packet-by-packet routing". On-board baseband processing made it possible to switch and multiplex user traffic according to destination into high-speed downlink carriers. That permitted the downlinks to operate with a single carrier per power amplifier, which, when operating near saturation, afforded the most efficient use of available transmitter power. Downlink transmission would be Time Division Multiple Access (TDMA) for hopping beams and Time Division Multiplex for fixed beams. The proposed transmission rate in most of the GEO systems was about 100 Mbps. For most on-board-processing Ka-band systems it was planned to use ISLs to provide direct user-to-user connection without the assistance of intermediate ground stations.

60. Several user terminals had been proposed for the Ka-band systems. A typical user terminal, operating at an uplink bit rate of between 128 and 768 Kbps, would employ a small-aperture antenna with a diameter of 66 cm and a solid-state power amplifier (SSPA) of 1-3 W. All radio frequency components (SSPA, low noise amplifier, and up/down-converters) would be integrated into a small outdoor unit mounted on the reflector. Gateway terminals would employ a larger antenna with a diameter of 2.4-5 metres and a high-power amplifier of 50-200 W.

61. For the Ka-band systems to be deployed in LEO, users might be able to employ smaller antennas. Their terminals must, however, be capable of tracking the satellites and performing a handover once every few minutes. Satellite handover in those systems also required precise timing coordination between satellite traffic routing and user terminal processing, as well as traffic-shaping at the user interfaces.

62. VSATs were available for operation in the C-band or Ku-band, but currently cost from $5,000 to $15,000, depending on their application. To be financially viable, the proposed Ka-band systems would need to be accessible by terminals costing considerably less (for example $1,000). To achieve such low prices required

mass production, which in turn required a commitment on the part of a system operator to a very large order (for example 1 million or more terminals), further increasing financial exposure.

1. Examples of proposed systems

63. EuroSkyWay was a multiregional network of interconnected Ka-band satellites being developed by Alenia Aerospazio to provide innovative and affordable services to business and consumer end-users. Low-cost and ultra-small-aperture user terminals were adopted to manage packet- and circuit-switched data traffic, with a flexible allocation of resources at the user's request.

64. The EuroSkyWay system represented a solution to providing multimedia services to users located within Europe, Africa and the Middle East with the possibility of integration with GII, as well as with other satellite or terrestrial wide-area networks.

65. The deployment of the EuroSkyWay system would be based on two different phases: the first operational phase envisaged two co-located satellites, providing coverage of Europe and nearby countries (in the Middle East and Mediterranean Africa and in some countries of the Commonwealth of Independent States); the second operational phase envisaged three additional satellites, to be integrated with the first-phase component, to increase capacity and to provide coverage of Africa (two satellites) and of the western part of Asia (one satellite).

66. The EuroSkyWay network was different from other proposed global satellite networks in that its geostationary orbit location, the selected link design and the novel traffic management scheme allowed for improved satellite resource utilization and overall service profitability. The cumulative high system throughput capacity (46 Gbps) obtained through a single cluster on five satellites, required smaller initial capital investments and satellite airtime from both service providers and end-users. The adopted digital transmission link design delivered an exceptional quality of service.

67. The Celestri system by Motorola was designed to provide near-global coverage with both geosynchronous orbit (GSO) and LEO satellites to provide the lowest-cost optimized broadband service for DTH small business and corporate terminals. The Celestri system would comprise the Celestri LEO system and two other systems also developed by Motorola: the Millennium and the M-Star systems. Celestri GSO used nine satellites to provide global coverage. By networking LEO with GEO satellites, the system would provide regional broadcast capabilities with real-time interactivity.

68. The Celestri Multimedia LEO was a constellation of 63 satellites in seven inclined orbital planes interconnected to nearly all of the populated land masses in the world. The planes were circular at a 1,400 kilometre altitude, inclined at 48 degrees with respect to the equator, which would enable operation to relatively low-power and low-cost Earth terminals with delays equivalent to those experienced with terrestrial systems. Each satellite contained all the hardware necessary to route communications traffic through the network, including Earth-to-space, space-to-Earth and space-to-space connections. Satellite-to-satellite interconnections used laser links, while Earth-to-space was in the 30 GHz band and space-to-Earth was in the 20 GHz band. Multi-beam phased arrays would provide fixed beams to give ubiquitous coverage through the satellite footprint. Data rates were from 64 Kbps to 155.52 Mbps.

69. The Celestri LEO system was designed to enable frequency sharing of the Ka-band spectrum with GSO and other LEO systems by using satellite diversity. The antennas formed a large number of narrow antenna beams. Beams that would cause interference with GSO or other LEO satellites operating at the same frequencies were turned off (blanked) and the communication was switched to another satellite with a different position. Switching was predictive, on the basis of known satellite positions. Ground terminals, as well as satellite

equipment, were commanded to provide beam blanking to avoid interfering geometries. No cooperation from the other system was required other than satellite positional data. Frequency sharing by satellite diversity made it possible to achieve valuable increases in the functionality of the limited spectrum resource.

70. The M-Star system had 72 operational LEO satellites in 12 inclined orbital planes. Orbits were circular at 1,350 km altitude. LEO was selected to enable small low-power and low-cost ground terminals to be used and to ensure that the delays experienced by end-users are essentially equivalent to domestic transport systems. Each satellite contained multiple bent-pipe transponders with spot-beam antennas. Intersatellite links connected each with four adjacent satellites. That architecture enabled signals to be transponded directly back to Earth or relayed to other satellites and then routed to any location globally. Service links operated in the 40 GHz band while intersatellite links were in the 60 GHz band. The system would offer voice and data transport to service providers and business customers and interconnection service to enable terrestrial carriers to aggregate voice or data signals.

71. The Alcatel Corporation had proposed a new system called SkyBridge, which would operate in Ku-band in order to reduce the rain fade problem, and was also designed to avoid interfering with existing geostationary Ku-band satellites. SkyBridge employed two constellations, each of 32 LEO satellites at 1,457 km altitude. Both constellations comprised four satellites equally spaced in each of eight orbital planes that were inclined at 55 degrees, and spaced 45 degrees apart at the equator. The two constellations were arranged to be offset from one another so that pairs of satellites crossed the sky. It was then possible to avoid interfering with geostationary satellites by commanding all Earth stations to cease using a SkyBridge satellite when it was within ±10 degrees of the geostationary arc, and to switch to the alternate satellite of the pair. While 387 gateway Earth stations would be needed to cover all the land areas between ±68 degrees latitude, only 253 would be needed to serve 90 per cent of the world's population.

72. SkyBridge would deliver an asymmetrical broadband connection to the fixed network, with up to 60 Mbps (in increments of 16 Kbps) to residential terminals and up to 2 Mbps (in increments of 16 Kbps) on the return link via a gateway. Higher bit rates would be accommodated by professional terminals. In addition, the small size of the increments would provide the user with bandwidth on demand.

73. The SkyBridge system was an ATM-based access network, providing the "last mile" connection between users and a local exchange. The traffic generated by terminals was transmitted transparently by the satellite (in other words without any processing other than amplification and frequency transposition) to the gateway and vice versa. In the case of terminal-to-terminal communications, the connectivity was established by the gateway switch, with a double hop. Each gateway collected, through the space segment, the terminal traffic within a 700 kilometre diameter cell. SkyBridge cells were permanently illuminated by at least one satellite spot beam. In most cases in temperate latitudes, at least two satellites were permanently visible.

74. Under the SkyBridge system all users were required to employ at least two tracking antennas, which represented a cost penalty and might confine the use of the system to larger enterprises that could afford expensive terminals; it did, however, hold out a promise of higher service availability.

2. Stratospheric platforms

75. There were four general telecommunication architectures that could be used to deliver broadband WLL service to consumers. Two of those architectures were space-based: geostationary satellites and non-geostationary satellites. The other two were considered terrestrial: rooftop cellular-type millimetre wave repeaters and stratospheric relay platforms.

76. Intrinsic reasons relating to geometry and hardware engineering inevitably led to a technical conclusion that the greatest amount of communication capacity over global metropolitan areas, for an equivalent investment in equipment and bandwidth, would come from the stratospheric architecture. Accordingly, the greatest amount of broadband Internet capacity for the lowest cost would be provided to consumers via stratospheric telecommunications.

77. If bandwidth, antenna aperture, power and other technical factors were kept constant, the metropolitan capacity of a telecommunications system was equal to the number of spot beams that the system provided. The number of metropolitan area spot beams that a system could generate varied directly with the distance between the radio repeater and the coverage area until the line of sight approached the outer boundary of the metropolitan area, and inversely thereafter. For example, because of the constraints imposed by antenna size, for all practical purposes a single-building top repeater could generate at most six spot beams using a 60 degree sectorial antenna. At the other end of the continuum, a geostationary satellite could generate more than one spot beam per metropolitan area using typical state-of-the-art antenna apertures of 5 metres at 20/30 GHz.

78. A single stratospheric telecommunications platform at 21 kilometres altitude could, however, generate approximately 700-1,000 spot beams within a single metropolitan area, whereas a non-geostationary satellite at 500 km altitude would generate only 4 to 16 spot beams out to 100 kilometres from the centre of a metropolitan area. The stratospheric architecture thus yielded approximately 100 times greater metropolitan area capacity than the non-geostationary satellite orbit architecture, assuming the same bandwidth allocation.

79. Stratospheric and other broadband systems could be differentiated as high-density and low-density market segments. All space systems (geostationary and networked non-geostationary) were low-density architectures. They did an excellent job of providing some bandwidth everywhere, but could not compete with terrestrial architectures in providing maximum capacity in metropolitan areas. Stratospheric and ground-based millimetre wave systems were high-density architectures. Those designs excelled at delivering to metropolitan consumers the greatest value in terms of cost-per-unit bandwidth, but were not very cost-effective when it came to rural service.

80. It was therefore vitally important for developing countries to include stratospheric platforms, such as the Sky Station stratospheric platform, in their national telecommunications plans. If developing countries relied solely on satellites for their broadband links, they would find themselves in the situation of having only low-density broadband capability to meet high-density broadband demand. That would lock developing countries into an inferior information infrastructure, which would be inconsistent with the ITU mandate for global information development. Stratospheric telecommunications platform technology was currently available for global deployment, subject to frequency allocation approvals and national business arrangements.

3. Little LEO

81. ORBCOMM was deploying a constellation of 28 small communication satellites in orbit 775 kilometres above Earth. With help from a ground infrastructure of Gateway Earth Stations (GES), the satellites connected the ORBCOMM users to the worldwide telecommunication network. Partial service was already available and the system would be fully operational in 1998.

82. A message could be sent by a user to a remote subscriber communicator through any personal computer using standard communication protocols. The user would simply connect to the Gateway and send a message using his computer. The Gateway would relay the message to the appropriate satellite and on to the remote subscriber communicator. Inbound messages from remote subscribers would follow the same route, but in reverse. Those messages could be delivered via an active circuit, or be stored in memory at the Gateway for retrieval at the customer's convenience.

83. The ORBCOMM system also had the unique capability of determining and reporting the position of remote communicators to users. ORBCOMM communicators were designed to measure the Doppler shift on the signals downlinked from the satellite. Each satellite determined its own position using the Global Positioning System (GPS). By combining the Doppler measurements with satellite GPS data, a communicator was able to determine its own position, generally with an accuracy of better than 1,000 metres.

4. Broadcasting satellite systems

84. Radio was the most ubiquitous communication device in the world. There were over 2 billion radio sets in the world and over a 100 million sets were sold every year. In developing countries, for example, on average there was one radio station for every 2 million people; in industrialized nations, the ratio was one station for every 30,000 people.

85. The goal of WorldSpace was to bring cheap but high quality digital radio broadcasting to 3.5 billion people; it relied on a DAB system that worked by routing a radio signal through a VSAT up to a geostationary satellite. The satellite transmitted down the signal, which was picked up by millions of portable radio receivers. The new global infrastructure that WorldSpace was creating would enable broadcasters and advertisers to reach underserved emerging markets, including the Middle East, Africa, Asia, the Caribbean and Latin America. People in those areas would be able to receive digital sound broadcasting of unprecedented quality and diversity on a new type of radio needed to receive programmes from WorldSpace satellites.

86. There were three satellites, AmeriStar, AfriStar and AsiaStar, each weighing around 3,000 kilograms. All three would be in geostationary orbit. All three satellites had three spot beams, each representing a coverage area of approximately 14 million square kilometres for a single channel. It would be possible to broadcast up to 288 channels for talk radio, 144 for monophonic music, or 72 for high-fidelity sound.

87. Expected to be priced at $200, the portable WorldSpace receiver used several technologies to achieve the company's objectives of cost, size and reliability. The receiver consisted of the antenna, Starman chipset, audio amplifier, speakers, monitor and serial interface.

88. The radios would receive high-quality monophonic and near CD-standard stereo radio programmes transmitted in L-band (1,467 to 1,492 MHz) via WorldSpace's three communication satellites. The use of digital transmission technology allowed other services to be offered, including text, fax, e-mail and message-paging services. An antenna the size of a business card inside the receiver would receive the satellite signals. In addition, the receivers would be equipped for standard AM, FM and short-wave broadcasts. The main remaining unknown factor on the financial and technical side was the price of the portable radios. The initial price was estimated at about $200, beyond the reach of all but the region's middle class layer but still low enough to attract from 5 to 10 million listeners, the number needed to be financially viable.

C. Regional and national satellite systems

1. Lockheed Martin Intersputnik

89. With 22 member nations, Intersputnik had been providing international, regional and satellite communications for more than 25 years. With its recently established joint venture with Lockheed Martin, known as Lockheed Martin Intersputnik (LMI), both organizations would greatly enhance their capabilities. The satellites deployed by LMI would be flight-proven, high-performance A2100 spacecraft, built by Lockheed Martin Missiles & Space. The A2100 platforms, with a 15- year lifetime, would replace Russian-built satellites and offer a large increase in capacity, with 44 high-powered transponders operating both in C-band and Ku-

band. LMI would offer unique capabilities and expertise in providing state-of-the-art solutions that met user requirements with flexible tariffs and direct access to the space segment.

90. The first launch by the Proton launch vehicle was scheduled for late 1998 to place an LM-1 satellite in the 75 degree east longitude orbital slot. Three more would follow before the end of 2000. Intersputnik had 15 highly valuable orbital slots. Initially, LMI would provide broadcast, fixed telecommunications and VSAT services to customers in Eastern Europe, South Asia, Africa and the Commonwealth of Independent States. Later, LMI services would include DTH video and audio, and mobile services to customers worldwide. Annual revenue was expected to reach $300 million-$500 million by 2001 and to keep growing as more services were added.

2. Kupon satellite

91. In Russia, economic progress depended on efficient financial network services. Telecommunication was an essential part of banking technology. The Central Bank of Russia had developed the BANKIR Satellite Communication Network (SCN), which provided a powerful means of meeting today's essential telecommunication needs and the flexibility needed to develop future networks.

92. A new generation of Kupon satellites had been specially designed for VSAT applications with new VSAT technology developed in Russia. The first phase of network deployment had begun in 1997. The first Kupon satellite had been launched on 12 November 1997 to a 55 degrees east longitude orbital slot to support BANKIR SCN of the Central Bank of Russia. But it would also be able to serve Europe, Africa, the Middle East and most of Asia and the Pacific Rim. The three planned satellites would provide virtually global coverage.

93. Kupon satellites would use the latest technologies, previously only available for military and governmental communications. They included multi-beam receive-and-transmit antennas, electronically steerable beams, in-orbit footprint size and shape control, dynamic power distribution between the beams and on-board traffic switching between the transponders. Those advanced features provided for extended built-in flexibility in network services and a wide range of applications.

94. The use of active on-board phased-array antennas provided for very high flexibility and system reliability. Each Kupon satellite had 24 (expandable to 32) Ku-band medium power transponders and 16 pairs of independent receive-and-transmit spot beams. Kupon transponders and footprints could be instantly reconfigured to meet a wide range of the ever-changing needs of customers.

4. AMOS satellite

95. The AMOS satellite communications system had been initiated as a commercial venture in January 1992. The AMOS-1 satellite had been launched successfully in May 1996 and communication services begun on 1 July 1996. The AMOS satellite was a new lightweight geostationary communication satellite with a launch weight of less than 1,000 kilograms and a three-axis attitude control subsystem. It carried a communication payload in the Ku-band, with seven active transponders (out of nine), of 72 bandwidths each.

96. Communication services were provided to the two main service areas: the Middle East (centred over Israel) and Central Europe (centred over Hungary). The allocation of the active transponders between the two service areas was provided by a ground command. There was a possibility for cross-connection between the two service areas: to uplink from one and downlink to the other. The AMOS satellite had a 750,000 square kilometre footprint. The technical features of AMOS, such as high, effective isotropic irradiated power at 55 dBW at the centre of the footprint allowed for numerous video, voice, and data communication services, as well as traditional broadcasting.

D. Advanced communication technology

97. Gilat Satellite Networks Ltd. designed, developed, manufactured, marketed and supported VSAT satellite Earth stations and related hub equipment and software. The company had more than 37 per cent of the world market share in 1996. The company's products were incorporated into telecommunication networks that provided satellite-based communications between a central location and a large number of geographically dispersed sites.

98. The company offered a range of products: Skystar Advantage, which made interactive, transaction-oriented applications possible; FaraWay VSAT offered multi-channel, toll-quality telephone service; DialAway VSAT offered single-channel, near toll-quality telephone service; SkySurfer VSAT delivered satellite-based Internet access; and OneWay VSAT provided unidirectional data broadcasts. The company's equipment was used for numerous applications, including credit card authorization, lottery transactions, pipeline monitoring, distance education, corporate telephony applications and paging. Next generation VSAT products were being designed to provide from 10 to 100 times the current throughput capacity to transmit text, voice and video signal in real time.

99. Gilat VSAT telephone products were an excellent solution to the problem of providing basic telephone services in remote locations. Potential users of VSAT rural telephony were rural communities served by public call offices, business users, local authorities and tourists at remote sites.

100. Techsat - I spacecraft had been developed by the Technion Institute. It was light (50 kg), inexpensive, with low power consumption (10 W) and three-axis stabilized. All those features made the platform well-suited for various applications. Currently two types of application-oriented satellites were being developed: SensTech microsatellite for high-resolution remote sensing and ComTech for communications. Two platforms were already at the manufacturing stage, and one of them was expected to be launched by the end of 1997.

101. The ISL in the global satellite projects used microwave radiation as the carrier. Free space optical communication between satellites networked together could make high-speed communication possible between different places on Earth. The advantages of an optical communication system instead of a microwave communication system in free space were: (a) smaller size and weight; (b) less transmitter power; (c) larger bandwidth; and (d) higher immunity to interference. The pointing from one satellite to another was a complicated problem owing to the great distance between the satellites, the narrow laser beam divergence angle and vibration of the pointing system. Vibration of the transmitted beam in the receiver plane decreased the average received signal, thus increasing the bit error rate.

102. Recent advances in the development of directly pumped solar lasers provided new opportunities for the increasing demand for both bandwidth and power for space communication. Using a unique technique for concentrating the solar light, splitting the spectrum to various spectral bands, and using each band for direct optical pumping of different lasers near their emission band resulted in an overall efficiency of 20 per cent. The lasers used in the experiments were Alexandrite, tunable in the range between 750 and 900 nanometres and various crystals doped with neodymium active in the region of between 1.054 and 1.064 microns. The bandwidth could be further extended by frequency doubling and optical multichannel oscillators. A collecting mirror with a 2 m diameter could provide total laser power of more than 500 W. That power was sufficient for communication between low-orbit and high-orbit satellites and provided better conditions for penetrating the atmosphere. Another application of that technology was power transmission between satellites.

103. Participants were shown tests of the DTX-360 digital circuit multiplication equipment. Each DTX-360 terminal accepted up to 360 trunk channels carrying 64 Kbps signals. The system provided for a high

compression ratio of up to 10:1 for speech and of up to 6:1 for fax. System tests demonstrated its suitability for usage in operational satellite networks.

E. International regulations for the use of radio spectrum

104. The international regulatory regime governing the use of spectrum/orbit resources was contained in the Radio Regulations, which complemented the International Telecommunication Union Constitution/Convention.

105. The procedures laid down in the Radio Regulations allowed member States of ITU to meet their requirements in terms of orbit/spectrum resources, ensuring on the one hand equitable access to and on the other hand efficient use of those limited resources.

106. The explosive growth of the use of satellites by various services offered great benefits to mankind yet the current growth in their numbers posed a threat to the Radio Astronomy and Earth Exploration services. Downlink emissions could be particularly damaging and already the emissions of some satellite systems had severely curtailed radio astronomy observations. Some forthcoming satellites posed a similar threat. In building space vehicles, the highest engineering standards should not be sacrificed in favour of economic arguments. In particular, electro-magnetic environmental impact statements must be required before space-borne transmitter systems were launched.

F. Examples of applications of communication satellites in the telecommunication infrastructures of selected economies in transition

Belarus

107. Despite the fact that Belarus had long been a member of Intersputnik, the International Telecommunications Satellite Organization (INTELSAT) and the International Mobile Satellite Organization (Inmarsat), it had only recently become involved in specific communication satellite-related projects, with the commissioning on 1 November 1996 of Belarus Teleport, consisting of two INTELSAT standard B earth stations with 11 m diameter antennas. One of those operated via Intersputnik's Express-6 satellite to provide services in the Indian Ocean region with a throughput capacity of 512 Kbps. The second one operated via an INTELSAT satellite to provide services in the Atlantic Ocean region with a throughput capacity of 2,048 Kbps. Half of that capacity was intended for Internet access. There were plans to install two more earth stations at the Teleport premises, to provide services for the Middle Asia and Caucasus regions. Negotiations were in progress to establish a satellite-based link between Belarus and Israel.

Estonia

108. As terrestrial public mobile communication networks were highly developed, there would be no major need for satellite communications in Estonia. By August 1997 there were about 85,000 customers of public mobile telephone radio communication networks. Current penetration of mobile services in Estonia was 6.1 per cent for a population of 1.5 million. Currently, Estonia used satellite communication channels via the Inmarsat, mostly for maritime mobile communications. There were also a few cases of Inmarsat land-mobile terminals being used. There were also satellite earth stations for broadcasting and data communication.

Lithuania

109. At the beginning of 1996, there were 940,977 subscribers (751,725 in urban areas and 189,252 in rural areas) serviced by the Lithuanian telecommunication networks. The overall capacity of the automatic telephone exchanges was 1,058,454 numbers (77.6 per cent in urban areas and 22.4 per cent in rural areas). Seven

powerful, 13 low-powered and two medium-wave State radio and television stations operated in Lithuania. They had 53 television and 61 radio transmitters, including 49 ultra-short-radio-wave transmitters. The State operated 1,147 km of radio relay lines. There were over 40 private radio transmitters and 16 private television transmitters. Forty-two licences had been granted to private enterprises to set up and operate cable television networks.

110. The Ministry of Communications and Informatics had signed cooperation agreements with Denmark, Finland, Germany, the Netherlands, Poland, Russia, Sweden and Ukraine. Contacts with Greece and Israel had been established. A target density of 35-40 telephones per 100 inhabitants was planned for Lithuania for 2000. For that purpose, new digital automatic telephone exchanges, with a capacity for 360,000-500,000 numbers, must be set up within five years. The main satellite systems used in the country were the European Organization of Telecommunications Satellites (EUTELSAT) and INTELSAT. The most powerful Earth station (2 Mbps) was still the most important bridge to Canada and the United States of America. There were more than 100 EUTELTRAC and about 40 Inmarsat terminals registered in Lithuania.

Poland

111. Poland had joined world and regional satellite organizations like INTELSAT, Inmarsat, Intersputnik and EUTELSAT. The Satellite Communication Centre had been created in Central Poland with satellite earth stations operating with the above-mentioned satellite organizations. Satellite communication in Poland was limited to fixed satellite service operating in the Ku-band and using the geostationary satellites of EUTELSAT, INTELSAT, Dividends from Space (DFS), Kopernikus and ORION F1. The C-band was not available for satellite service owing to high occupancy by fixed services.

112. The possibilities introduced by new legislation and the development of private business in the country had led to the submission of a considerable number of satellite licence applications. The country's inadequate and obsolete telecommunication infrastructure had been replaced and completed by the dynamic development of domestic VSAT networks. There were currently VSAT networks belonging to seven independent private operators in the country, operating jointly about 1,000 VSAT terminals. The biggest network operated over 350 terminals.

Romania

113. Under the new legislation adopted by Romania in 1990 and with an undeveloped telecommunication infrastructure, many VSAT systems had been deployed. There were currently over 100 private VSAT system operators, in addition to a large number of private interactive star-shaped networks that were mainly transmitting data. VSAT networks for audio and video programmes were less widespread. The licensing procedures were simple and transparent, with very inexpensive licensing fees, and that had led to the existence of more than 850 operational VSAT terminals using the INTELSAT, EUTELSAT and ORION systems.

114. The use of mobile satellite services, in particular, through Inmarsat and plus EUTELSAT had started in Romania in 1990. In 1991 Romania had ratified the International Agreement on the Use of Ship Earth Stations within the Territorial Seas and Ports in order to free the way for the development of those services. There were no longer any restrictions on the use of the L-band frequency.

Notes

[1]See *Report of the Second United Nations Conference on the Exploration and Peaceful Uses of Outer Space, Vienna, 9-21 August 1982* (A/CONF.101/10 and Corr.1 and 2), Part One, sect. III.F, para. 430.